A typical lightning discharge transfers an amount of electric charge much less than what is in a single raindrop
An entire lightning storm may involve a thousand times that, or the amount of electric charge contained in a sip of water

Intermediate Electrodynamics

Physics 302 | Spring 2020

Approximately (it now seems) 5% of the matter and energy in the Universe consists of particles that interact through what we call the *electromagnetic force*, implicating a property of matter that we call *electric charge*. That 5% of the total matter and energy in the Universe makes up the world of our direct experience, and the objects and phenomena on which most of physics is focused. The other 95% -- dark matter and dark energy, the natures of which remain elusive -- becomes evident mainly at the large physical scales of galaxies and the Universe itself.

Electric charge occurs in two forms or polarities, arbitrarily distinguished by the designations positive (+) and negative (–). As far as we know, the net electric charge of the universe is zero, with negative and positive charges present in equal numbers, mostly as electrons and protons. The electric force is a long-range force, similar in geometric form to gravity, but some 10^{40} times stronger than gravity in common unshielded systems such as the interiors of atoms and molecules. Our direct macroscopic experience of the electric force is obscured by the shielding that is a consequence of its bi-polarity and, seemingly paradoxically, it's very great strength. Positive and negative electric charges attract and bind tenaciously to one another, and can be separated in large quantities and over large distance only under the force of extreme conditions. Such separated electric charges can induce violence by their tenacity to rejoin and restore charge neutrality. Terrestrial lightning is a familiar example of this phenomenon: a typical terrestrial lightning discharge involves the separation (and rejoining) of perhaps 15 coulombs of electric charge, comparable to the total electric charge -- all the protons and electrons -- contained in a milligram of water (equivalent to about 1% of a single raindrop). That same amount of electric charge can keep an electric hair dryer -- plugged into wall outlet -- running for only about one second . . . though the lightning bolt involves much higher energies.

The electrical force, acting between particles subject to the laws of classical and quantum mechanics, plays a principal role – in many respects, *the* principal role – in controlling the properties and behavior of the material world as we observe, experience, and manipulate it. The properties of inanimate and biological matter and their interactions, the nature of electromagnetic radiation, our means of intelligent communication and other information transfer, the design, fabrication, and operation of materials and devices, and the functioning of living systems all ultimately are controlled by the electric forces acting among the charged particles that make up matter. Electrodynamics is the study of the nature of electrical interactions.

Objectives: The aim of this course is to help students learn and use the elements of electrodynamics. Among specific topics to be covered are electrostatic and magnetostatic fields in vacuum and in matter; electrodynamics of time-varying fields; Maxwell's Equations; electromagnetic potentials, fields, waves and radiation; and the Special Theory of Relativity (for which electrodynamics provided the original motivation). An additional aim is to help

students develop facility with related mathematical topics and tools, including vector calculus, differential equations, special functions and tensors.

Coverage, Text and Materials

The textbook for this course is ***Introduction to Electrodynamics***, by David J. Griffiths, 4th edition, Cambridge University Press, 2017. [This Cambridge edition replaces the 2012 edition previously published by Pearson/Addison-Wesley; the Cambridge edition is identical but much less expensive].

Additional reference sources may, from time to time, be posted on the class website.

Facts

This course carries 4 semester-hours of course credit.
Lectures meet Tuesdays & Thursdays, 9:25-10:40am | Herman Brown Hall 227.
The Tuesday-afternoon session, which you are also expected to attend, meets at 2:30pm, HBH 227.
There will normally be a homework assignment, focused on problem solving, each week.
Examinations: Two take-home midterms (approximately late February & late March) and an in-class final examination during finals period at the end of the semester.

Instructor & Locations

Eugene H. Levy

ehl@rice.edu	http://ehl.web.rice.edu	713-348-4121
Office: Herman Brown Hall 318	Mail Delivery: MS-108	Hours flexible by appointment (email)

You are encouraged to consult or seek help from Professor Levy and/or the teaching assistants.

Teachng/Grading Assistants

Shixiao Liang: liangsx@rice.edu
Run Hou: rh48@rice.edu
} Office hours also flexible by appointment (email)

Class Structure & Attendance

Morning class lectures are two 75-minute sessions per week. Students should plan to be present for all regular classes. It is the student's responsibility to be aware of all assignments, tests, and due dates. The problem-solving, Tuesday-afternoon class session -- which will also occasionally take up additional or special topics not covered in the text or the morning lectures -- meets once per week; all students should plan to be present for that session also.

The class pace, averaging about a chapter of the textbook per week, constitutes a fast clip for covering the material in this course. Class lectures and discussion will focus on elucidating the main principles, but will not necessarily cover all of the subtopics in each chapter. However, except as otherwise instructed, students are responsible for all of the material in each chapter, and should expect to devote significant out-of-class effort to reading in the textbook, reviewing their notes taken in class, and working out example problems, as well as working up the homework assignments to be submitted and graded.

Class Websites

The Rice CANVAS course site will mainly be used for announcements and for distributing and collecting materials, including homework and tests. Scores and grades will be posted (anonymized under class-specific PIN numbers, which will be distributed to you), along with histograms that that allow you to see how you are doing in comparison with the class overall. These materials will be posted at a class website readily linkable from CANVAS as well as from a prominent button at: http://ehl.web.rice.edu/. The syllabus, along with updates if needed, will be posted there as well. [Scores and grades will not be posted on CANVAS.]

Syllabus. This syllabus conveys a general overview of the course. Students are responsible for being familiar with the syllabus and website, which may be revised during the semester. If substantive alterations are made, students will be given reasonable advance notice in class and on the class website.

Grading

The final grade will be weighted as Homework 30%; Mid-Term Tests 20% each; Final Examination 30%. Electrodynamics is inherently a cumulative subject; homework and tests will reflect that. The lowest two homework scores will automatically be disregarded. (This will also provide flexibility for life exigencies, such as illness, effects of extravagant parties, social and family issues, and the like.)

Generally, homework assignments will be distributed shortly after the Thursday class session and posted in the CANVAS Assignments folder for this class, and will be due before the following Thursday-morning class. Late homework will be subject to a grade penalty based on a 2-day decay constant: $P_a = P_e e^{-(t/\tau)}$, where P_e is the number of raw points earned by the graded homework, P_a is the number of points assigned to the student's grade record after applying the grade-decay factor, t is the time, in hours, that the assignment is late, and τ is the grade decay constant equal to 48 hours. To be graded at all, homework must be submitted within 48 hours of the due time.

It is the student's responsibility to submit work that is clearly structured, organized, lucid and legible. It is not the graders' or instructor's responsibility to decode or assemble arguments and solutions from among illegible or extraneous material, or to fill in significant blanks, logic, or missing steps.

Collaboration, Reference and Citation Policies & the Rice Honor Code

HOMEWORK. Unless otherwise instructed on a particular homework assignment or problem, students are encouraged to consult *general reference materials*, and to discuss or collaborate with one another. However, the work that each student hands in is to consist of his or her sole and independent work. Each student should conclude discussions and consultations on a homework problem before then undertaking, on his or her own, to render and submit the solution to that problem.

EXAMINATIONS. All submitted materials are to be the sole and independent work of each student To avoid making exams into memory gymnastic exercises, you will be provided with a formula sheet for reference. No other reference materials, books or notes will be permitted during the test. You will need to be able to recognize the important mathematical expressions, as well as be conversant with their meaning and use, but you need not spend your time memorizing formulas to prepare for exams in this class.

REFERENCE MATERIALS. With one exception, students may not consult homework or examination solutions from prior years; and may not consult solutions of specific homework problems from any sources. However, during the 7 days immediately prior to the midterm examination and during the end-of-semester reading and final exam period, students are free study from any resources whatever.

RICE HONOR CODE. All graded work in this class is subject to the Rice Honor Code. Students are expected to be scrupulous about the independence of their work when that is required. Violations will be reported to Rice Honor Council, and be handled by the Honor Council. Questions or lack of clarity about issues of academic integrity should be raised with the instructor at the earliest possible time.

Disabilities & Accommodations

Rice and the instructor are committed to broad access, and feasibly equal opportunity, to education. Rice's Disability Support Services Office (DSS; Allen Center, Room 111; 713-348-584; adarice@rice.edu) supports and implements applicable federal guidelines and laws. Students with documented disabilities requiring accommodation under Rice's established policies should consult DSS and the instructor; consultations and accommodations will be held confidential to the extent reasonably feasible.

Machines in the Classroom

Cell phones are to be turned off – or rendered silent – within the classroom. Laptops or other portable devices may be used in class for class-specific purposes such as taking notes (though this subject may not be conducive for taking notes on a computer). If you have need to be available for an urgent call, please set your phone to vibrate and take the call out of the classroom.